Implementing Methods to Improve Perioperative Hemostasis in the Surgical and Trauma Settings

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Learning Objectives

After completing this activity, participants should be able to:

- Compare and contrast the safety, efficacy, and costs of available adjunct topical hemostatic agents
- Interpret and apply current data to promote responsible treatment selection
- Implement methods to improve hemostatic practice in the surgical and trauma settings

Target Audience

This educational activity is designed for perioperative nurses.

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ABSTRACT

Achieving perioperative hemostasis is vital to surgical success. Inadequate control of bleeding is associated with serious adverse outcomes, including extended duration of surgery, unanticipated blood transfusions, shock, infection, impaired wound healing, longer hospital stays, and mortality. Appropriate clinical management of bleeding in the surgical and trauma settings requires careful collaborative planning and coordination by the entire perioperative team. Perioperative nurses, because of their strategic role in patient care, must be familiar with risk factors for excessive bleeding and the fundamental roles of hemostatic agents, environmental temperature, and blood transfusion in controlling bleeding in the surgical patient. Knowledge of the characteristics, safety, efficacy, and costs of available topical hemostatic agents promotes their appropriate selection in the OR. By incorporating evidence-based approaches into practice, perioperative nurses can support effective intraoperative hemostasis, thereby improving patient outcomes. *AORN J* 92 (November 2010) 1-15. © AORN, Inc, 2010.

Key words: *hemostasis, porcine gelatin, bovine collagen, oxidized regenerated cellulose, polysaccharide spheres, bovine thrombin, pooled human thrombin, recombinant thrombin, immune-mediated coagulopathy, fibrin sealant.*

Achieving perioperative hemostasis through internal mechanisms or clinical interventions is vital to surgical success. Inadequate control of bleeding is associated with serious adverse outcomes during and after a surgical procedure, including unanticipated blood transfusions and related risks of exposure to blood products, shock, infection, impaired wound healing, and mortality.[1-3] Hemostatic challenges in surgery can vary based on the amount of blood loss, generally categorized as minimal bleeding, moderate-yet-controlled bleeding, and uncontrolled bleeding typical in trauma cases. Extended duration of surgery, longer hospital stays, and other care-related issues associated with perioperative bleeding also increase the costs of care.[1-3]

The continuum of care in the surgical and trauma settings is managed by a multidisciplinary team of surgeons, anesthesia care providers, nurses, and technologists, the constitution of which varies according to the type of surgery and the clinical condition of the patient. Improving hemostatic practices is notably relevant to perioperative nurses because of their strategic role in patient care. Nurse responsibilities in the OR include maintenance of a sterile environment,

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coordination of patient care, and anticipation of equipment needs. Furthermore, perioperative nurses frequently assist in the assessment of intraoperative bleeding, handle and prepare topical hemostatic agents, and order blood products when necessary.

General aspects of intraoperative hemostasis and the use of topical hemostatic agents are discussed in this article to advance education on hemostatic practice in the surgical and trauma settings. Given the array of available topical hemostatic agents and approved indications, there may not be a single optimal agent choice in a particular clinical scenario; however, some agents may be clearly inappropriate in specific circumstances. Perioperative nurses, therefore, require knowledge of individual risk factors for excessive bleeding and of the safety, efficacy, and costs of available topical hemostatic agents to facilitate their appropriate selection during surgery. By incorporating evidence-based approaches into practice, perioperative nurses can support effective intraoperative hemostasis, thereby improving patient outcomes.

PRINCIPLES OF COAGULATION

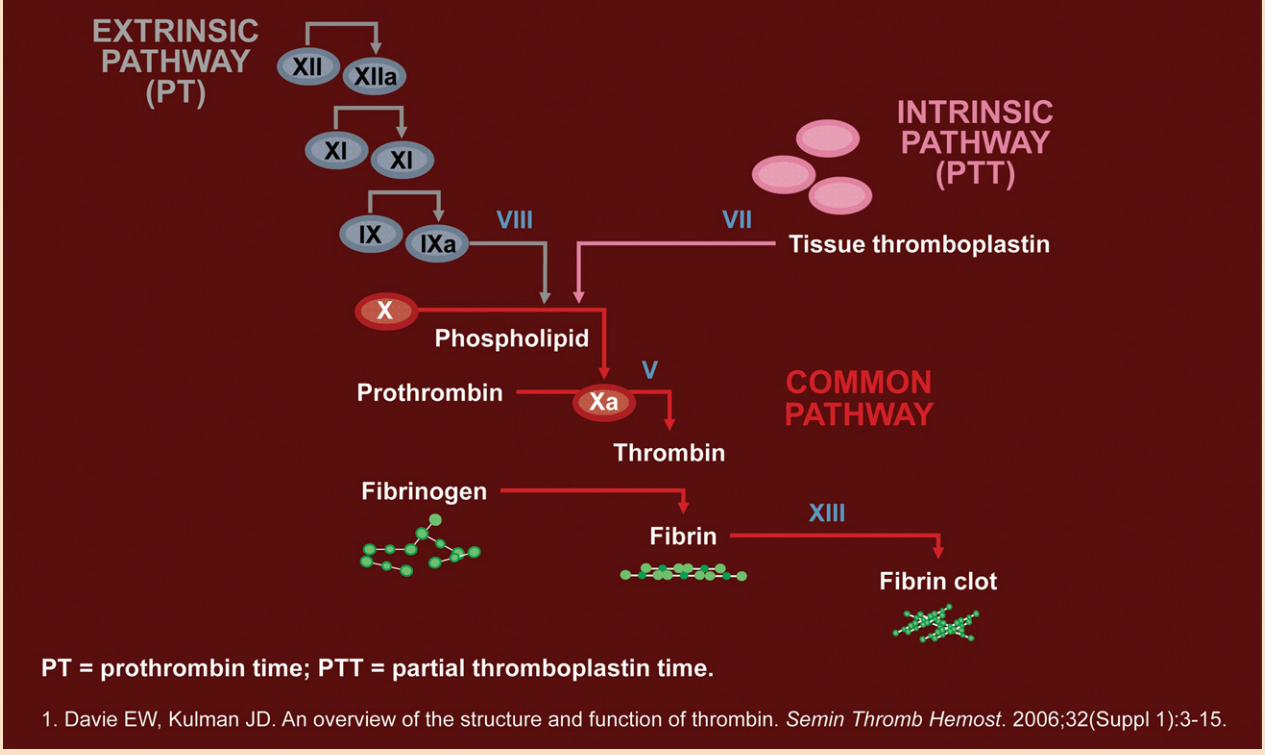
In patients with a functional coagulation cascade, the process of coagulation is initiated with injury-induced disruption to a blood vessel.[3,4] Tissue external to the blood vessel is exposed to blood cells, endothelial cells, clotting factors, and other substances that flow through the bloodstream.[3,4] During primary hemostasis, platelets are activated to adhere to the broken surface of the blood vessel and to each other, forming a temporary plug.[3,4] Clotting factors in the bloodstream are then activated, prompting a protein-based process known as the coagulation cascade, in which thrombin is generated to form fibrin.[3,4] Ultimately, fibrin mesh combines with the aggregated platelets to stabilize the platelet plug and form a mechanical fibrin clot at the bleeding site, which prevents further blood loss.[3,4]

The coagulation cascade is a complex process that involves multiple interactions and coagulation factor activations, all of which are required for proper coagulation function (Figure 1).[5] Stated simply, the coagulation cascade involves an intrinsic (ie, contact activation) pathway, measured by partial thromboplastin time, or an extrinsic (ie, tissue factor) pathway, measured by prothrombin time.[5] Either of these pathways can activate a common pathway, whereby factor X, in the presence of factor V, is activated; prothrombin is subsequently cleaved to release thrombin, which, in turn, converts fibrinogen to fibrin.[5,6]

Patient conditions or environmental factors may impede clot formation. Hemostasis can be hindered by platelet abnormalities, such as thrombocytopenia, which is especially common among oncology patients undergoing chemotherapy.[3,4] Patients with renal failure have normal platelet levels, but their platelet function is compromised because of uremia.[7] Platelet function also may be impaired by antiplatelet medications, such as aspirin, clopidogrel, or prasugrel, which are frequently administered to reduce the risk of heart attack and stroke or to treat peripheral artery disease.[3,8] Clot inhibition also can be attributable to an abnormality in the coagulation cascade associated with use of therapeutic anticoagulation medications, such as heparin or warfarin,[3,8] and also may occur in conjunction with sepsis, cirrhosis, autoimmune disorders, or consumptive conditions that have depleted the patient's coagulation factors.[3] Less commonly, a patient may have an inherited coagulation abnormality, such as von Willebrand disease.[9]

Intraoperative hypothermia exemplifies an environmental factor that inhibits clot formation because the coagulation cascade is less efficient at lower temperatures.[3,4] Hypothermia constitutes a greater risk in patients with select preoperative risk factors (eg, low body weight, advanced age, low blood pressure, low heart rate)[10] and is more likely to occur in patients experiencing acute blood loss.[2] A meta-analysis of 14 studies that

Figure 1. Coagulation Cascade[1]



PT = prothrombin time; PTT = partial thromboplastin time.

1. Davie EW, Kulman JD. An overview of the structure and function of thrombin. *Semin Thromb Hemost*. 2006;32(Suppl 1):3-15.

compared blood loss and transfusion requirements in more than 2,000 normothermic and mildly hypothermic surgical patients revealed that less than one degree of hypothermia increased blood loss during surgery by 16% ($P < .009$) and increased the risk of transfusion by 22% ($P < .027$).[11] Frequent monitoring of temperature and rewarming measures may improve hypothermia-related patient outcomes.[12]

METHODS OF ACHIEVING HEMOSTASIS

Optimal hemostasis generally occurs when surgical technique controls all surgical sources of bleeding and the patient's own coagulation system effectively seals microvascular sources of bleeding. In this favorable situation, no additional hemostatic management is necessary; however, ideal OR situations do not always transpire. Perioperative measures should be focused on achieving satisfactory hemostasis without resorting to transfusion. Even when blood-product transfusion is unavoidable, the amount that needs to be administered may be minimized by implementing measures that reduce blood loss or that enhance the patient's own hemostatic mechanisms. Clinical options include adequate surgical technique that controls all discrete large vessel bleeding, attention to the physiologic state of the patient (eg, temperature, pH), and the use of topical hemostatic products.

Hemostasis challenges and associated interventions vary in accordance with bleeding severity (ie, minimal, moderate yet controlled, uncontrolled). Achieving local hemostasis can be accomplished through a variety of strategies; in cases that involve minimal or moderate bleeding, surgical teams may consider direct application of

a topical hemostat to the bleeding surface.[3] Hemostasis may also be achieved endogenously by allowing the patient's physiologic system to reach hemostasis naturally or by using supplemental techniques of compression or packing.[3]

Select surgical or trauma situations may require use of systemic hemostasis strategies. For example, the surgical team can anticipate and reduce bleeding problems in patients who are taking warfarin by preoperatively administering vitamin K.[3] Patients receiving heparin before surgery or receiving intentional intraoperative heparin administration may require administration of protamine.[3] When it is otherwise unavoidable, fresh frozen plasma, cryoprecipitate, and platelets may be replaced via transfusion to reverse preoperative or intraoperative coagulopathy.[3] Factor VII, a clotting factor that accelerates clot formation, can be administered in crisis situations.[3]

In all cases, there is a consistent objective to support hemostasis by maintaining the patient's normal body temperature.[3] Low body temperature can prevent blood from coagulating normally, which underscores the role of the perioperative nurse to closely monitor the patient's temperature, obtain and operate rewarming equipment, and increase room temperature when necessary to promote hemostasis. Acid-base balance, or pH, which is critical to the functioning of body systems, also can affect coagulation.[3]

Successful achievement of hemostasis through mechanical or systemic methods can avert the need for transfusion, which is associated with a high risk of adverse clinical outcomes.[1,2,13] A prospective, multicenter, observational cohort study of nearly 5,000 patients in intensive care found that the number of red blood cell transfusions a patient received during the study period was independently associated with an extended length of stay in the intensive care unit, a longer total hospital length of stay, a greater number of complications, and an increased risk of mortality.[1] The leading cause of transfusion-related morbidity and mortality is transfusion-related acute lung injury, which occurs in approximately one of 500 platelet transfusions and one of 1,000 to 5,000 plasma and red blood cell transfusions.[2,13] Other leading causes of transfusion-related morbidity and mortality include bacterial contamination of platelets, which occurs in one of every 2,000 to 3,000 transfusions, as well as transfusion-related immunomodulation and transfusion-associated circulatory overload.[2,13]

Achieving and maintaining hemostasis is further complicated in the trauma surgery setting, during which hypothermia, acidosis, and coagulopathy, typically known as the "lethal triad" of trauma, interact in a vicious cycle to compromise patient outcomes.[14] Trauma patients are often hypothermic on arrival to the surgical suite, which exacerbates coagulopathy and interferes with hemostasis.[14] Acidosis that results from hemorrhagic shock also promotes coagulopathy and impairs blood clotting mechanisms.[14] Hypothermia and acidosis further potentiate coagulopathy, with ongoing bleeding leading to continued hypothermia and acidosis.[14] Perioperative nurses should give special consideration to this subset of conditions to effectively manage trauma patients. The presence of these conditions tends to increase the hemostatic challenge and may affect the choice of adjunctive topical agent. As discussed in the following section, certain agents rely more than others on the integrity of the patient's own coagulation cascade. In these more critical clinical scenarios, the patient's own coagulation system may not be able to effectively contribute to the formation of a clot.

TOPICAL HEMOSTASIS OPTIONS

Topical hemostats are agents that may allow surgical teams to achieve hemostasis when traditional surgical methods are ineffective or inappropriate, but they are not a substitute for adequate surgical technique. In other words, they will not work effectively when the bleeding should be controlled by suture or electrosurgery.[15,16] Use of topical hemostats may be indicated when the

surgical team is dealing with bleeding from diffuse raw surfaces with a multitude of bleeding points; bleeding close to the bone; bleeding around delicate structures, including nerves; bleeding in inaccessible locations; needle-hole bleeding; and bleeding during laparoscopic or robotic surgery.[15,16]

Various topical agents are available, and they all fall into one of four categories:

- mechanical hemostats,
- active hemostats,
- flowables, and
- fibrin sealants.[15]

These types of agents vary in efficacy, the degree to which they depend on the patient's own coagulation system for effectiveness, and cost.[15]

Mechanical Agents

Mechanical methods incorporate the topical hemostat into an absorbable format, such as a sponge or pad; options include porcine gelatin (eg, Gelfoam®, Surgifoam®), bovine collagen (eg, Avitene®, Helistat®), oxidized regenerated cellulose (eg, Surgicel®), and microporous polysaccharide spheres (eg, Arísta™).[15] The efficacy of mechanical agents requires an intact coagulation cascade to ensure that fibrin can ultimately be produced after application of the mechanical agent.[6] Thus, these agents will not be effective nor should they be relied on when hemorrhage is caused by a significant coagulopathy. Mechanical agents accelerate the coagulation cascade to promote time-sensitive control of bleeding, and efficacy varies among products; bovine collagen is typically the most efficacious, given that it also activates platelets, followed by porcine gelatins, polysaccharide spheres, and oxidized regenerated cellulose.[15] In general, the more efficacious agents cost more.[15]

Mechanical agents are associated with certain adverse effects, some of which the perioperative nurse may be able to prevent or minimize. Spotnitz and Burks[15] have extensively addressed the issues involved in the use of mechanical hemostatic agents. Mechanical agents may require up to six weeks to be fully absorbed, with the exception of Arísta, which is absorbed within 48 hours.[15] During the absorption process, the presence of the foreign body in the wound can predispose the patient to infection.[15] Fluid absorption by the mechanical agent causes swelling and underscores the need for meticulous agent placement.[15] For example, surgeons should avoid placement in a small space adjacent to a nerve, because swelling may cause impaired nerve function.[15] Accordingly, mechanical agents should not be placed proximate to the spinal foramina, where nerve roots exit the spinal cord.[15] If mechanical agents must be used in small or sensitive areas, then they should be removed by the end of the surgical procedure.[15] Likewise, the introduction of a foreign body may inhibit skin or bone wound healing. Mechanical agents should not be introduced into the bloodstream, and perioperative nurses should be aware of this warning when a cell saver is being used.[15] Finally, although some mechanical agents can be safely combined with thrombin, the acidity of cellulose may neutralize the effectiveness of thrombin or other sealants by altering the pH of the microenvironment.[15] In general, clinicians should use the smallest quantity possible to achieve the desired effect.[15]

Active Agents (Topical Thrombin)

The three available active hemostatic agents, outlined in Figure 2, are bovine thrombin (eg, Thrombin-JMI®), pooled human plasma thrombin (eg, Evithrom®), and recombinant thrombin (eg, Recothrom®).[6,15]

The thrombins short-circuit the coagulation cascade by adding the crucial enzymatic end product directly to the bleeding site and enabling topical thrombin cleavage of fibrinogen to produce the fibrin clot.[6,15] Thrombins are practical when the patient's own coagulation system is impaired because of heparinization, mild coagulopathy, or other conditions.[6,15] These agents are unlikely to be effective as a stand-alone interven-

Figure 2. Topical Thrombin Derivatives

	Plasma Source	Efficacy	Adverse Event Profile	Formulation/ Storage	Cost (AWP)[1]
Bovine	Yes	"Gold standard"	Immunogenic (cases of IMC)	Powder/ room temperature	+
Pooled human	Yes	Equivalent to bovine	Potential for infection	Liquid/ refrigerate	++++
Recombinant	No	Equivalent to bovine	Potential for allergic reaction	Powder/ room temperature	++

AWP = average wholesale price; IMC = immune-mediated coagulopathy.

1. University of Utah Pharmacy, Salt Lake City, e-mail communication, January 2010.

tion in cases of profound coagulopathy, especially in patients with hypofibrinogenemia.[15] Topical thrombins are more effective than mechanical hemostats at arresting local bleeding, but they are also generally more expensive.[15]

The therapeutic use of thrombin has an extensive history, with bovine thrombin first clinically used by surgeons in World War II and the Korean War.[17,18] The US Food and Drug Administration (FDA) officially granted approval of bovine thrombin use in the 1970s; the product currently on the market, Thrombin-JMI, received approval in 1995.[17,18] In 1996, however, the FDA required manufacturers to include a black box warning on the package insert regarding postoperative bleeding after bovine thrombin use caused by activation of the human immune system. The warning further outlined the increased likelihood of antibody formation with repeated use and advised against use in patients who are taking antibodies.[17,18] Two additional thrombin products were developed to circumvent the immunogenicity issue; the FDA approved pooled human plasma thrombin in 2007 and recombinant thrombin in 2008.[17,18]

Bovine and pooled human plasma thrombin are both derived from plasma, a complex mixture of proteins. Bovine and human thrombin are purified from plasma pools by using chromatography, then activated to produce thrombin.[19] The purification procedure for bovine thrombin has been enhanced to minimize undesirable bovine plasma proteins, such as factor V, that activate the human immune system.[19] The human thrombin purification process focuses on testing for and exclusion of potentially transmissible infectious agents, such as hepatitis viruses and HIV.[19] Recombinant human

thrombin is produced by using genetic techniques; the human prothrombin gene is introduced into Chinese hamster ovary cells, which then use their own protein synthetic machinery to produce human prothrombin.[20] During purification, the thrombin precursor is cleaved to thrombin by using a protease derived from snake protein.[20]

The approved thrombin products have demonstrated comparative efficacy in achieving hemostasis.[16,21] For example, in a phase 3, double-blind, comparative study, 401 patients were randomly assigned to receive either recombinant thrombin or bovine thrombin.[16] Hemostasis was achieved within 10 minutes in 95% of both patient groups.[16] Similar results were obtained during a head-to-head comparison of pooled human thrombin with bovine thrombin.[21]

Clinicians should take special precautions when administering topical thrombin, in particular, by avoiding intravascular use of all thrombin products. Thus, care should be taken to avoid uptake of these products by a cell saver. Adverse effects are typically product specific. Bovine thrombin use is associated with immunogenicity; therefore, repeated doses are contraindicated.[22] In the phase 3 trial previously discussed, 21.5% of patients to whom bovine thrombin was administered exhibited immune system activation, testing positive for antiproduct antibodies by day 29, compared with 1.5% of patients to whom recombinant thrombin was administered ($P < .0001$)[16]; the rates of immune system activation in other studies range from 13% to 95%.[16] As stated earlier, the package insert for bovine thrombin includes a black box warning that repeated applications increase the likelihood of antibody formation and that patients with antibodies to bovine thrombin preparations should not be re-exposed to these products.[22] These precautions are difficult to implement because a patient's medical record may not include all previous instances of bovine thrombin exposure, and there is no clinically available test to detect the presence of antibodies. Approximately 60 cases of immune-mediated coagulopathy related to bovine thrombin use have been reported in the past 20 years.[23] Although there is evidence that episodes of immune-mediated coagulopathy have decreased since 2000 with improved purification methods,[17] cases continued to be reported as recently as 2008.[24]

Pooled human thrombin is associated with a risk for transmission of infection.[21] Human thrombin is derived from large pools of human plasma, with up to 60,000 donors represented per lot of human thrombin.[25] Despite extensive testing of both donors and plasma for hepatitis A, B, and C; HIV; and parvovirus, there is still a residual risk for hepatitis A and parvovirus infection and a theoretical risk of variant Creutzfeldt-Jakob disease caused by prion transmission.[15,21,25]

Recombinant thrombin has the theoretical potential to cause allergic reactions attributable to exposure of the product to hamster and snake proteins during the manufacturing process.[20] Therefore, patients with a pre-existing sensitivity to hamsters or snakes may be at higher risk for an adverse reaction to recombinant thrombin.[20] During preoperative intake and evaluation, it is appropriate for perioperative nurses to ask patients about these sensitivities as well as sensitivities to animal products used to make mechanical hemostatic agents, such as pork or beef.

Thrombin products vary in cost; in general, bovine thrombin is least expensive, recombinant thrombin is approximately 20% more expensive than bovine thrombin, and pooled human thrombin is the most expensive thrombin product. Prices will vary depending on specific purchasing arrangements established by each hospital. For example, average wholesale thrombin prices quoted by the pharmacy at the University of Utah, Salt Lake City (e-mail communication, January 2010), are as follows:

- Thrombin-JMI (bovine): $86.12 for 5,000 units/viral load (vL) and $339.65 for 20,000 units/vL;

- Recothrom (recombinant): $103.20 for 5,000 international unit kit and $412.80 for 20,000 international unit kit; and
- Evithrom (pooled human): $691.20 for a 5-mL vial and $2,587.50 for a 20-mL vial.

Flowables

Flowables (eg, FloSeal®, Surgiflo®) combine a mechanical hemostat and an active hemostat into a single application format.[15] The products are a mix of human plasma thrombin with either bovine collagen gelatin or porcine collagen gelatin. Human plasma thrombin, which is typically reconstituted as a liquid and can thus run off the bleeding surface, has a solid or pasty consistency when combined with a gelatin.[15] Therefore, flowable hemostatic agents remain in place more effectively than does the liquid thrombin alone.[15]

Clinical trials have demonstrated that flowables are highly effective at achieving hemostasis.[26,27] In a multicenter trial, 93 cardiac surgery patients were randomly assigned to receive either FloSeal or Gelfoam plus thrombin.[26] Researchers found that 94% of patients who received FloSeal exhibited complete cessation of bleeding within 10 minutes compared with 60% of patients who received Gelfoam® plus thrombin ($P < .001$).[26] For bleeding sites categorized as "heavy," 77% of patients who received FloSeal achieved hemostasis at three minutes compared with 0% of patients who received Gelfoam® plus thrombin ($P < .001$).[26] A multicenter, prospective, single-arm study evaluated the hemostatic effectiveness of Surgiflo in 30 patients undergoing revision endoscopic sinus surgery for chronic sinusitis[27]; the researchers found that 96.7% of patients achieved hemostasis within 10 minutes of product application, with a median total time to hemostasis, including manual compression, of 61 seconds.[27]

Fibrin Sealants

Fibrin sealants (eg, Tisseel®, Crosseal®, Hemaseel®, Evicel®) are effective in patients with coagulopathy who do not have sufficient fibrinogen to form a clot.[15,28] Fibrin sealants work by combining human thrombin with its target fibrinogen in a single product to create fibrin.[15,28] Active bleeding is not necessary for fibrin sealants to be effective.[15,28] Fibrin sealants are multicomponent products that contain fibrinogen, factor XIII, thrombin, fibronectin, and ionized calcium.[28] Tisseel also contains aprotinin, a bovine-derived antifibrinolytic, to counteract fibrinolysis by plasmin. Unlike Tisseel, Crosseal and Hemaseel are made from human products, including concentrated human plasma and purified human thrombin, and thus do not carry the risk of anaphylactic reaction that Tisseel does, although they do carry the risk of infectious disease transmission.[28]

Fibrin sealants are commonly used in open surgeries and are becoming more popular in controlling hemostasis in laparoscopic surgeries.[28] Typically, fibrin sealants are used as adjunctive therapy when thermal or chemical hemostatic methods fail or are insufficient to achieve hemostasis.[28] Fibrin sealants, however, have been used in laparoscopic surgery as a primary hemostatic strategy.[28] Preparation and administration of fibrin sealants is more complicated than that of other topical hemostats; the application system involves two administration syringes, one that contains thrombin and calcium and one that contains fibrinogen, fibronectin, and factor XIII,[28] because thrombin and fibrinogen must be separated until immediately before application to the bleeding site to prevent premature clot formation. Unlike the other three fibrin sealants, Evicel is a frozen liquid, but it requires less than one minute of preparation time after thawing.[28]

Results of research studies have supported the efficacy of fibrin sealants in achieving hemostasis.[29] In a multicenter trial, 121 patients undergoing liver resection were randomly assigned to receive treatment with either Crosseal or another standard topical hemostatic agent, such as Surgicel or Gelfoam.[29] The mean time to hemostasis was 282 seconds with Crosseal compared with 468 seconds with standard agents ($P = .06$); hemostasis

Nursing Considerations

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Experience-based anticipation and appropriate clinical management of bleeding in the surgical and trauma settings can minimize the incidence of adverse outcomes associated with failure to achieve hemostasis. Implementation of interventions for intraoperative bleeding requires careful collaborative planning and coordination by the entire perioperative team. Appropriate and timely response to transfusion reactions, shock, and infection can reduce mortality rates, length of stay, and procedure-related costs.[1] As essential members of the OR team, perioperative nurses require familiarity with the fundamental roles of hemostatic agents, environmental temperature, and blood transfusion in controlling bleeding in the perioperative patient.

Successfully used in a variety of medical, dental, and surgical settings since the 1970s, hemostatic agents allow for local application of clotting factors to a bleeding site and control bleeding by promoting the conversion of fibrinogen to fibrin.[2,3] Because hemostatic agents are derived from either bovine or human thrombin, associated risks include immunogenicity, foreign body responses, infection, and impaired skin or bone wound healing.[2,3] Problems with antibody development to factor V and infectious disease have declined because of improvement in the production of human thrombin and because of the development of recombinant human thrombin and fibrin preparations.[2]

Nursing involvement with agent use entails three primary responsibilities, the first of which is preprocedural consultation with the surgeon regarding agents to be ordered to ensure the availability of those agents in the surgical suite. Second, nurses assist with preparation and administration of the agents as indicated. Finally, it is crucial for the nurse to document any and all administered agents in the patient record because of the concern for antibody formation and anaphylaxis with any repeated exposure, especially to bovine thrombin preparations.[4] As a part of the follow-up process, health care facility personnel are encouraged to provide a standardized letter to patients who have received hemostatic agents that instructs them to share this medication history with future health care providers.

Control of environmental temperature is another key strategy in the management of intraoperative bleeding. Patients lose body heat from conductive, convective, evaporative, and radiative mechanisms while they are in the surgical suite.[2] Mild hypothermia is defined as a core body temperature between 34° C and 36° C (93.2°F and 96.8° F); moderate hypothermia, between 32° C and 34° C (89.6° F and 93.2° F); and severe hypothermia, lower than 32° C (89.6° F).[2] Physiologic consequences of hypothermia include impaired oxygen delivery caused by a left shift of the oxyhemoglobin dissociation curve, decreased cardiac output, increased risk of dysrhythmias, infection, electrolyte abnormalities, and coagulopathy.[2] For each 1° C (1.8° F) drop in body temperature, there is a corresponding 10% decrease in coagulation factor activity.[2] Since the mid-1980s, clinical evidence has associated hypothermia with an increased risk of uncontrolled bleeding and mortality, especially in trauma patients.[2] Hypothermia-induced coagulopathies are multifactorial and may be attributable to platelet dysfunction as a result of delayed response time, splenic sequestration, and altered morphology; the hypothermic liver does not produce coagulation enzymes.[5] Furthermore, fibrinolysis is enhanced in the hypothermic setting.[5,6] These conditions underscore

(continued)

continued

the crucial role of the perioperative nurse in maintaining an appropriate room temperature in the operating suite, applying convective warming devices when practical, and using fluid warmers with the administration of IV fluids and blood products.

A final discussion point germane to the management of perioperative hemostasis is the perioperative nurse's role in transfusion of blood and blood products. Specific blood products will be selected by the anesthesiologist or the surgeon; however, the nurse is responsible for

- ordering the products,
- confirming their prompt delivery,
- helping to verify the received products against patient identification,
- assisting with agent preparation and administration, and
- assuring appropriate documentation.

Evolving experience in military settings may advance existing administration methods for traditional ratios of packed red blood cells, fresh frozen plasma, and even the use of fresh whole blood in civilian practice in the coming years.[7-10] The use of hemostatic adjuncts, such as recombinant factor VIIa, antifibrinolytics, and plasma protein concentrate in massive transfusion scenarios may change with the release of promising research results. Therefore, it behooves the nurse to be aware of updates in transfusion practices, including the recently published red blood cell transfusion guidelines for critical care.[10] The perioperative team should review, discuss, and adapt evidence-based recommendations to address the unique needs of its clinical environment.

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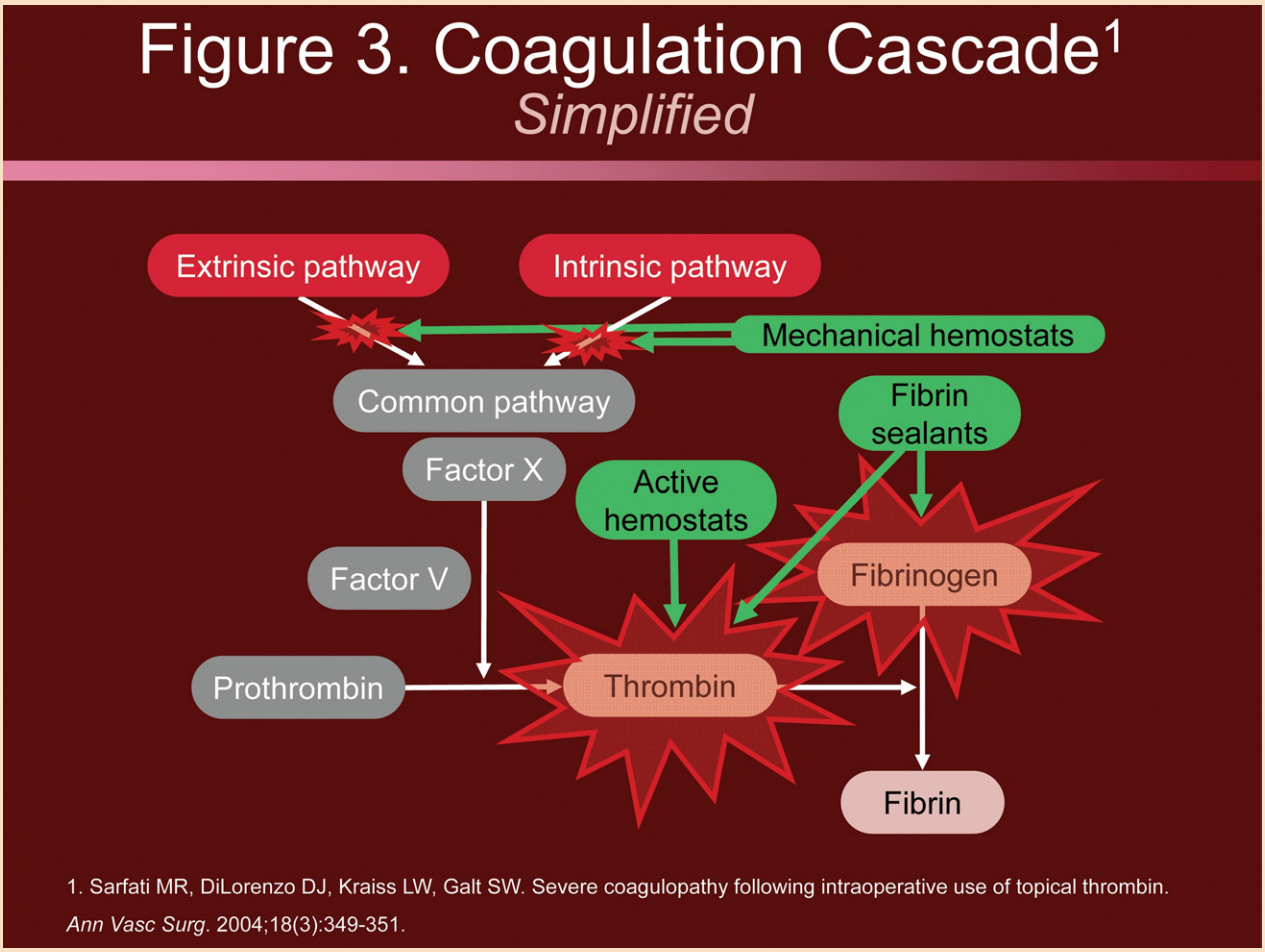

was achieved within 10 minutes in 91.4% of patients who received Crosseal compared with 69.8% of patients treated with other topical hemostats (P = .003).[29] Furthermore, the percentage of patients that developed postoperative complications was 17.2% of patients who received Crosseal compared with 36.5% of patients who received a standard topical hemostatic agent.[29]

CONCLUSION

As essential members of the surgical team, perioperative nurses benefit from knowledge regarding the various topical hemostats to facilitate selection of the most appropriate agent in each case. Topical hemostatic agents, which include mechanical hemostats, active hemostats (ie, thrombins), flowables, and fibrin sealants, vary in efficacy and adverse effect profiles. Optimal use of topical hemostats involves matching their efficacy with the magnitude of the hemostatic challenge. That different topical hemostats interact with the coagulation cascade at different levels is emphasized in Figure 3. Mechanical hemostats are most appropriate for mild bleeding problems, whereas use of a fibrin sealant in this instance would most likely be unnecessary and not cost-effective. Reliance on mechanical hemostats in the case of a profound coagulopathy, however, would be ineffective and likely a waste of time and opportunity; in these situations, use of agents with more biologic activity, such as fibrin sealants, is more appropriate. Key concerns include

- immunogenicity associated with repeated bovine thrombin use,
- appropriate placement of mechanical agents to avoid nerve impairment caused by swelling,

- potential allergic reactions to animal products used in manufacturing recombinant thrombin, and
- avoidance of uptake of mechanical and active hemostats when cell savers are in use.

Perioperative nurses also play a valuable role in monitoring and responding to hypothermia, which impedes clot formation and increases the risk of transfusion, and in identifying differences among topical hemostats with regard to formulation, storage, and preparation. By incorporating evidence-based recommendations for the use of topical hemostats into practice, perioperative nurses contribute to ensuring the safe and effective treatment of surgical and trauma patients. AORN

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